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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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CHRISTENSEN, O'CONNOR, JOHNSON, KINDNESS, PLLC
1420 FIFTH AVENUE
SUITE 2800
SEATTLE, WA 98101-2347

EXAMINER	
WONG, EDNA	
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)
	10/700,782	KIM ET AL.
	Examiner	Art Unit
	Edna Wong	1795

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *25 October 2007*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *20-37,44 and 45* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *20-37,44 and 45* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

This is in response to the Amendment dated October 25, 2007. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office Action.

Response to Arguments

Specification

The disclosure has been objected to because of minor informalities.

The objection of the disclosure has been withdrawn in view of Applicants' amendment.

Claim Rejections - 35 USC § 103

I. Claims **20- 28** have been rejected under 35 U.S.C. 103(a) as being unpatentable over **Cohen** (US Patent No. 6,869,515 B2) in combination with **Tzanavaras et al.** (US Patent No. 5,421,987), **Bokisa** (US Patent No. 6,676,823 B1) and **Dubin et al.** (US Patent No. 5,972,192).

The rejection of claims 20-28 under 35 U.S.C. 103(a) as being unpatentable over Cohen in combination with Tzanavaras et al., Bokisa and Dubin et al. has been withdrawn in view of Applicants' remarks.

II. Claims **29-37** have been rejected under 35 U.S.C. 103(a) as being unpatentable over **Cohen** (US Patent No. 6,869,515 B2) in combination with **Tzanavaras et al.** (US

Patent No. 5,421,987), **Bokisa** (US Patent No. 6,676,823 B1) and **Dubin et al.** (US Patent No. 5,972,192).

The rejection of claims 29-37 under 35 U.S.C. 103(a) as being unpatentable over Cohen in combination with Tzanavaras et al., Bokisa and Dubin et al. has been withdrawn in view of Applicants' remarks.

III. Claims **20-23 and 25-28** have been rejected under 35 U.S.C. 103(a) as being unpatentable over **Dubin et al.** (US Patent No. 5,972,192) in combination with **Bokisa** (US Patent No. 6,676,823 B1).

The rejection of claims 20-23 and 25-28 under 35 U.S.C. 103(a) as being unpatentable over Dubin et al. in combination with Bokisa has been withdrawn in view of Applicants' remarks.

IV. Claim **24** has been rejected under 35 U.S.C. 103(a) as being unpatentable over **Dubin et al.** (US Patent No. 5,972,192) in combination with **Bokisa** (US Patent No. 6,676,823 B1) as applied to claims 20-23 and 25-28 above, and further in view of **Cohen** (US Patent No. 6,869,515 B2) and **Tzanavaras et al.** (US Patent No. 5,421,987).

The rejection of claim 24 under 35 U.S.C. 103(a) as being unpatentable over Dubin et al. in combination with Bokisa as applied to claims 20-23 and 25-28 above, and further in view of Cohen and Tzanavaras et al. has been withdrawn in view of

Applicants' remarks.

V. Claims **29-32 and 34-37** have been rejected under 35 U.S.C. 103(a) as being unpatentable over **Dubin et al.** (US Patent No. 5,972,192) in combination with **Bokisa** (US Patent No. 6,676,823 B1).

The rejection of claims 29-32 and 34-37 under 35 U.S.C. 103(a) as being unpatentable over Dubin et al. in combination with Bokisa has been withdrawn in view of Applicants' remarks.

VI. Claim **33** has been rejected under 35 U.S.C. 103(a) as being unpatentable over **Dubin et al.** (US Patent No. 5,972,192) in combination with **Bokisa** (US Patent No. 6,676,823 B1) as applied to claims 29-32 and 34-37 above, and further in view of **Cohen** (US Patent No. 6,869,515 B2) and **Tzanavaras et al.** (US Patent No. 5,421,987).

The rejection of claim 33 under 35 U.S.C. 103(a) as being unpatentable over Dubin et al. in combination with Bokisa as applied to claims 29-32 and 34-37 above, and further in view of Cohen and Tzanavaras et al. has been withdrawn in view of Applicants' remarks.

Response to Amendment

Declaration

The declaration filed on October 25, 2007 under 37 CFR 1.131 is sufficient to overcome the **Cohen** (US Patent No. 6,869,515 B2) and **Bokisa** (US Patent No. 6,676,823 B1) references.

Claim Rejections - 35 USC § 103

I. Claims **20-22 and 25-28** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Schmidt** ("Structure and Properties of Copper Coating Electrodeposited at High Current Densities", *Galvanotechnik* (1991), Vol. 82, No. 11, pp. 3800-3818) in combination with **Morrissey et al.** (US Patent No. 6,679,983 B2) and **Ruythooren et al.** ("Electrodeposition for the Synthesis of Mircosystems", *J. Micromech. Microeng.*, Vol. 10 (2000), pp. 101-107).

Schmidt teaches a process for electroplating copper on a microelectronic workpiece in a through-mask plating application at a rate of at least 2 μm/min, said process comprising:

(a) providing a plating bath comprising:

(1) Cu^{2+} (= $CuSO_4 \cdot 5\ H_2O$);

(2) H_2SO_4 (= H_2SO_4);

(3) Cl^- (= Cl-containing baths); and

(4) water (*inherent*);

(b) providing a workpiece (*inherent*);

(c) contacting said workpiece with said plating bath (*inherent*);

(d) providing electroplating power between said workpiece and an anode disposed in electrical contact with said bath (= electroplated); and

(e) depositing copper (= a Cu electroplate) onto said workpiece at a rate of at least 2 μm/min (= from a current density of ≤ 200 A/dm^2) [abstract].

The current density of said electroplating power is 100-300 mA/cm^2 (= a current density of ≤ 200 A/dm^2) [abstract].

The current density of said electroplating power is 150-220 mA/cm^2 (= a current density of ≤ 200 A/dm^2) [abstract].

The bath has a temperature of 25-35°C (= room temperature).

The process of Schmidt differs from the instant invention because Schmidt does not disclose the following:

a. Wherein the plating bath comprises a brightener, as recited in claim 20.

b. Wherein the plating bath comprises a wetting agent, as recited in claim 20.

Like Schmidt, Morrissey teaches electrodepositing copper. Morrissey teaches that electroplating articles with copper coatings is generally well known in the industry. Electroplating methods involve passing a current between two electrodes in a plating solution where one electrode is the article to be plated. A common plating solution would be an acid copper plating solution containing (1) a dissolved copper salt (such as

copper sulfate), (2) an acidic electrolyte (such as sulfuric acid) in an amount sufficient to impart conductivity to the bath and (3) additives (such as surfactants, brighteners, levelers and suppressants) to enhance the effectiveness and quality of plating (col. 1, lines 13-25).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the plating bath described by Schmidt with wherein the plating bath comprises a brightener; and wherein the plating bath comprises a wetting agent because additives such as surfactants and brighteners are common in an acid copper plating solution and would have enhanced the effectiveness and quality of plating as taught by Morrissey (col. 1, lines 13-25).

c. Wherein the workpiece is a microelectronic workpiece having one or more through-mask openings with a conductive layer at the bottom of said opening, as recited in claim 20.

Like Schmidt, Ruythooren teaches electrodepositing copper. Ruythooren teaches that copper is deposited on a thin seed layer in a through-mask plating for copper interconnects (page 103, Fig. 2). An electrolyte solution containing the metal ions that will be deposited in the form of salts (e.g., $CuSO_4$), supporting chemicals such as acids or salts (e.g., H_2SO_4 or NaCl) and additives (e.g., saccharine) is used (page 101, col. 2, lines 1-4).

It would have been obvious to one having ordinary skill in the art at the time the

invention was made to have modified the workpiece described by Schmidt with wherein the workpiece is a microelectronic workpiece having one or more through-mask openings with a conductive layer at the bottom of said opening because such a plating bath would have been used in a through-mask plating process for electrodepositing copper interconnects as taught by Ruythooren (page 101, col. 2, lines 1-4; and page 103, Fig. 2).

d. Wherein the depositing step further comprising depositing copper to form a deposited feature having a smooth surface morphology, as recited in claim 26.

e. Wherein the depositing step further comprising depositing copper to form a deposited feature that has a substantially flat surface, as recited in claim 27.

f. Wherein the depositing step further comprising depositing copper to form a deposited feature that has a thickness variation of less than 10%, as recited in claim 28.

Schmidt teaches that the Cu electroplates show a uniform structural and high quality appearance (abstract).

The invention as a whole would have been obvious to one having ordinary skill in the art at the time the invention was made because the Schmidt combination teaches a depositing step in a similar manner as instantly claimed. Therefore, one having ordinary skill in the art would have expected that similar processes can reasonably be expected to yield similar results (MPEP § 2112(III)).

II. Claim **23** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Schmidt** ("Structure and Properties of Copper Coating Electrodeposited at High Current Densities", *Galvanotechnik* (1991), Vol. 82, No. 11, pp. 3800-3818) in combination with **Morrissey et al.** (US Patent No. 6,679,983 B2) and **Ruythooren et al.** ("Electrodeposition for the Synthesis of Mircosystems", *J. Micromech. Microeng.*, Vol. 10 (2000), pp. 101-107) as applied to claims 20-22 and 25-28 above, and further in view of **Dubin et al.** (US Patent No. 5,972,192).

Schmidt, Morrissey and Ruythooren are as applied above and incorporated herein.

The process of Schmidt differs from the instant invention because Schmidt does not disclose wherein the waveform of said electroplating power is a DC and a pulse with a 10-50% duty cycle at 50-1000 Hz, as recited in claim 23.

Like Schmidt, Dubin teaches electrodepositing copper. Dubin teaches that the present invention addresses such reliability problems by providing a method wherein high aspect ratio openings in a dielectric layer are filled voidlessly with improved uniformity and increased grain size, thereby improving reliability and increasing electromigration resistance (col. 5, lines 32-37). In pulse electroplating, the thickness of the diffusion layer formed at the solution-electrode interface during plating is reduced, since Cu ions diffuse to the cathode surface while the current pulse is off. Pulse electroplating is generally employed in metal finishing industries and comprises, in its simplest sense, metal deposition by pulse electrolysis, as by interrupted DC current, to

electroplate parts. This is effected with *__a series of pulses of DC current__* of equal amplitude and duration in the same direction, separated by periods of zero current. The pulse rate (frequency) and ON and OFF interval x (duty cycle) are controllable to optimize electrodeposition in a particular situation. Pulse electroplating can be conducted by utilizing a constant current or with constant voltage pulses. In employing pulse electroplating in accordance with the present invention, one having ordinary skill in the art could easily optimize the relevant variables, such as the duty cycle, frequency and current density in a particular situation (col. 5, lines 50-67).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the waveform of said electroplating power described by Schmidt with wherein the waveform of said electroplating power is a DC and a pulse with a 10-50% duty cycle at 50-1000 Hz because high aspect ratio openings in a dielectric layer would have been filled voidlessly with improved uniformity and increased grain size, thereby improving reliability and increasing electromigration resistance as taught by Dubin (col. 5, lines 32-37).

Dubin teaches that Cu was electroplated to fill both trenches by employing unipolar (i.e., forward) pulse plating with a duty cycle of about 10% to about 90%, frequency of about 1 to about 1000 Hz and a current density of about 5 to about 50 mA/cm^2 (col. 8, Example 1).

III. Claim **24** is rejected under 35 U.S.C. 103(a) as being unpatentable over

Schmidt ("Structure and Properties of Copper Coating Electrodeposited at High Current Densities", *Galvanotechnik* (1991), Vol. 82, No. 11, pp. 3800-3818) in combination with **Morrissey et al.** (US Patent No. 6,679,983 B2) and **Ruythooren et al.** ("Electrodeposition for the Synthesis of Mircosystems", *J. Micromech. Microeng.*, Vol. 10 (2000), pp. 101-107) as applied to claims 20-22 and 25-28 above, and further in view of **Tzanavaras et al.** (US Patent No. 5,421,987).

Schmidt, Morrissey and Ruythooren are as applied above and incorporated herein.

The process of Schmidt differs from the instant invention because Schmidt does not disclose wherein the workpiece is rotated at a speed of 20-200 revolutions per minute and wherein said bath flows against said workpiece at a flow rate of 1-10 gallons per minute, as recited in claim 24.

Like Schmidt, Tzanavaras teaches electroplating through patterned masks. Tzanavaras teaches that the workpiece is rotated (= a stationary anode/jet assembly with a rotating substrate assembly) [col. 8, lines 46-57] at a speed of 20-200 revolutions per minute (= a rotation speed of more than about 80 revolutions per minute) [col. 5, lines 33-39] and wherein said bath flows against said workpiece at a flow rate of 1-10 gallons per minute (= 0.25-10.0 gallons per minute) [col. 8, lines 37-40].

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the workpiece and bath described by Schmidt with wherein the workpiece is rotated at a speed of 20-200 revolutions per minute and

wherein said bath flows against said workpiece at a flow rate of 1-10 gallons per minute because using a rotating anode/jet assembly (RAJA) would have significantly improved both macro and micro-uniformities (thickness and composition) while facilitating significantly higher current densities and plating rates. The rotating anode/jet assembly (RAJA) would have produced high pressure and turbulent jets with a uniform flow distribution across the cathode (or substrate) surface as taught by Tzanavaras (col. 2, line 58 to col. 3, line 4).

IV. Claims **29-31 and 34-37** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Schmidt** ("Structure and Properties of Copper Coating Electrodeposited at High Current Densities", *Galvanotechnik* (1991), Vol. 82, No. 11, pp. 3800-3818) in combination with **Morrissey et al.** (US Patent No. 6,679,983 B2) and **Ruythooren et al.** ("Electrodeposition for the Synthesis of Mircosystems", *J. Micromech. Microeng.*, Vol. 10 (2000), pp. 101-107).

Schmidt, Morrissey and Ruythooren are as applied as discussed above and incorporated herein.

The process of Schmidt differs from the instant invention because Schmidt does not disclose wherein the plating bath comprises a leveler, as recited in claim 29.

Like Schmidt, Morrissey teaches electrodepositing copper. Morrissey teaches that electroplating articles with copper coatings is generally well known in the industry. Electroplating methods involve passing a current between two electrodes in a plating

solution where one electrode is the article to be plated. A common plating solution would be an acid copper plating solution containing (1) a dissolved copper salt (such as copper sulfate), (2) an acidic electrolyte (such as sulfuric acid) in an amount sufficient to impart conductivity to the bath and (3) additives (such as surfactants, brighteners, levelers and suppressants) to enhance the effectiveness and quality of plating (col. 1, lines 13-25).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the plating bath described by Schmidt with the plating bath comprises a leveler because additives such as levelers are common in an acid copper plating solution and would have enhanced the effectiveness and quality of plating as taught by Morrissey (col. 1, lines 13-25).

V. Claim **32** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Schmidt** ("Structure and Properties of Copper Coating Electrodeposited at High Current Densities", *Galvanotechnik* (1991), Vol. 82, No. 11, pp. 3800-3818) in combination with **Morrissey et al.** (US Patent No. 6,679,983 B2) and **Ruythooren et al.** ("Electrodeposition for the Synthesis of Mircosystems", *J. Micromech. Microeng.*, Vol. 10 (2000), pp. 101-107) as applied to claims 29-31 and 34-37 above, and further in view of **Dubin et al.** (US Patent No. 5,972,192).

Schmidt, Morrissey, Ruythooren and Dubin are as applied as discussed above and incorporated herein.

VI. Claim **33** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Schmidt** ("Structure and Properties of Copper Coating Electrodeposited at High Current Densities", *Galvanotechnik* (1991), Vol. 82, No. 11, pp. 3800-3818) in combination with **Morrissey et al.** (US Patent No. 6,679,983 B2) and **Ruythooren et al.** ("Electrodeposition for the Synthesis of Mircosystems", *J. Micromech. Microeng.*, Vol. 10 (2000), pp. 101-107) as applied to claims 29-31 and 34-37 above, and further in view of **Tzanavaras et al.** (US Patent No. 5.421,987).

Schmidt, Morrissey, Ruythooren and Tzanavaras are as applied as discussed above and incorporated herein.

VII. Claim **44** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Schmidt** ("Structure and Properties of Copper Coating Electrodeposited at High Current Densities", *Galvanotechnik* (1991), Vol. 82, No. 11, pp. 3800-3818) in combination with **Morrissey et al.** (US Patent No. 6,679,983 B2) and **Ruythooren et al.** ("Electrodeposition for the Synthesis of Mircosystems", *J. Micromech. Microeng.*, Vol. 10 (2000), pp. 101-107).

Schmidt, Morrissey and Ruythooren are as applied as discussed above and incorporated herein.

Schmidt also teaches depositing copper (= a Cu electroplate) onto said workpiece at a rate in the range of about 4 μm/min to about 6 μm/min (= from a current density of ≤ 200 A/dm^2) [abstract].

VIII. Claim **45** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Schmidt** ("Structure and Properties of Copper Coating Electrodeposited at High Current Densities", *Galvanotechnik* (1991), Vol. 82, No. 11, pp. 3800-3818) in combination with **Morrissey et al.** (US Patent No. 6,679,983 B2) and **Ruythooren et al.** ("Electrodeposition for the Synthesis of Mircosystems", *J. Micromech. Microeng.*, Vol. 10 (2000), pp. 101-107).

Schmidt, Morrissey and Ruythooren are as applied as discussed above and incorporated herein.

Schmidt also teaches depositing copper (= a Cu electroplate) onto said workpiece at a rate in the range of about 4 μm/min to about 6 μm/min (= from a current density of ≤ 200 A/dm^2) [abstract].

Citations

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Buzhinskaya et al. ("Behavior of Chlorine in the Electrolysis of Copper with Insoluble Anodes and Air Agitation of the Electrolyte at High Current Densities", *Elektrokhimiya* (1970), Vol. 6, No. 3, pp. 315-317) is cited to teach the electrolysis of copper at a current density of from 1000 to 25000 A/m^2 (abstract).

Glenn (US Patent No. 3,963,588) is cited to teach a high current density electroplating using a coalescent-jet apparatus. Copper is electrodeposited (col. 2, lines

25-30).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Edna Wong whose telephone number is (571) 272-1349. The examiner can normally be reached on Mon-Fri 7:30 am to 4:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen can be reached on (571) 272-1342. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Edna Wong
Primary Examiner
Art Unit 1795

EW
November 14, 2007